GPS Time and Frequency Transfer Operations at NIST

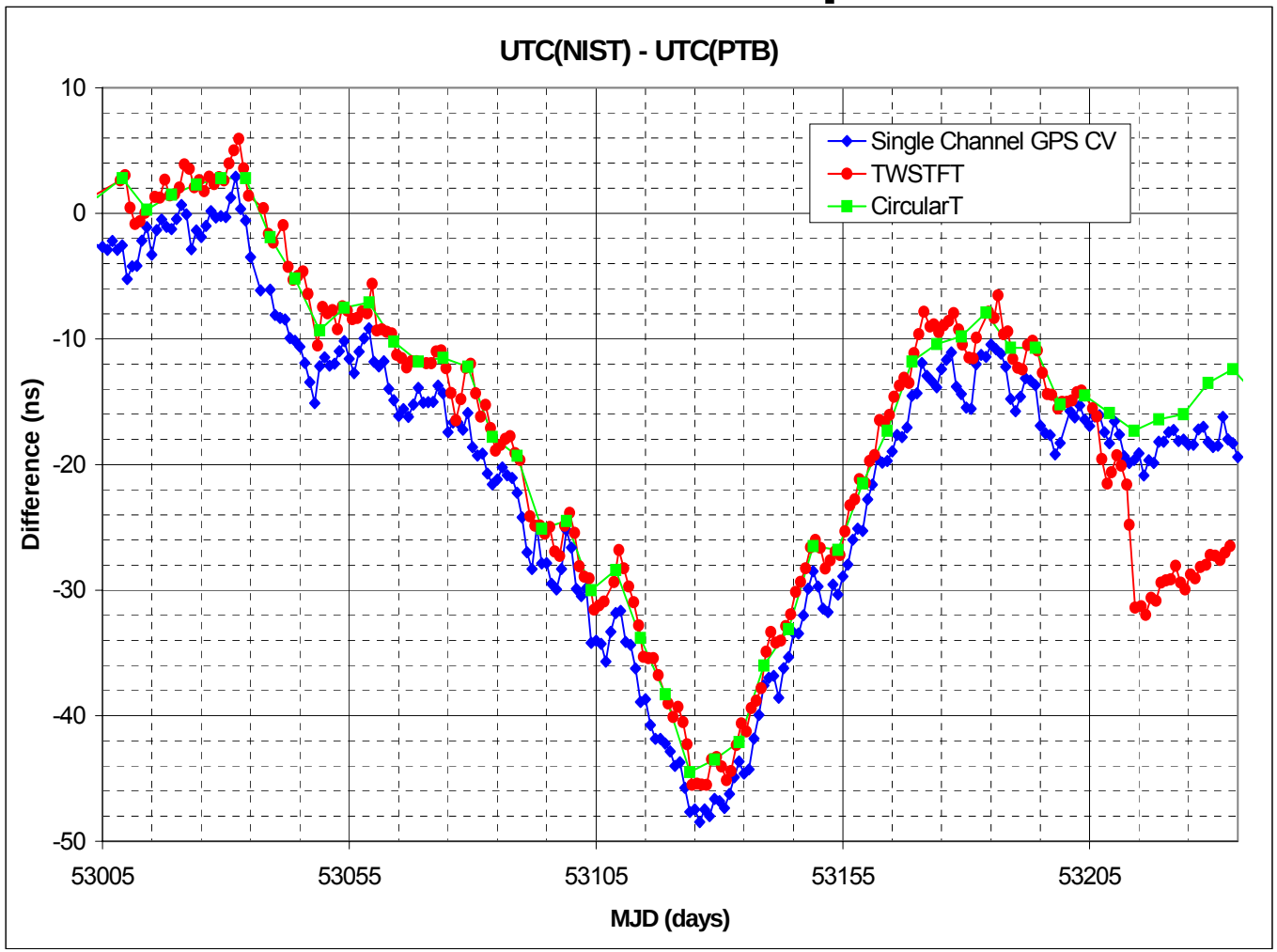
Victor Zhang

National Institute of Standards and Technology
Time and Frequency Division

Overview

- Common-view Time and Frequency Transfer
- One-way Time and Frequency Transfer
- Carrier-phase Frequency Transfer

Common-view Operation at NIST



Secondary method for contributing NIST time scale to the computation of TAI and UTC

Common-view Operation at NIST

Global Time Service (Service ID No.76110S)

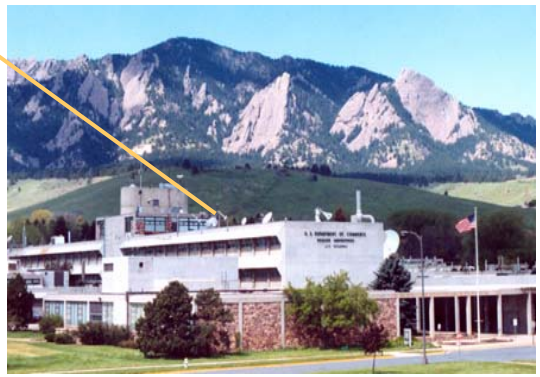
- Calibrate remote clock with respect to UTC(NIST)
- σ_x < 10 ns @ 1 day, σ_y < 1 x 10^{-13} @ 1 day
- Daily preliminary analysis and monthly report
- Serves timing laboratories, research laboratories, telecom industry, GPS receiver manufacturers
- Information about the Global Time Service
  http://ts.nist.gov/ts/htdocs/230/233/calibrations/time_freq/timeindex.htm

Common-view Operation at NIST

Synchronize radio stations' clock to UTC(NIST)

WWV/WWVB in Fort Collins, CO

WWVH in Hawaii



NIST in Boulder, CO

One-way Operation at NIST

Monitor GPS signal (NIST GPS Data Archive)

- Make 1 pulse per second (1 PPS) measurements of UTC(NIST) - GPS for each GPS satellite when it is in view at NIST (Boulder, Colorado)
- Measurements are reduced to 10-minute average, 1-hour average, and 1-day average for UTC(NIST) – GPS and UTC(NIST) – GPS PRN
- Results are updated daily at

  http://tf.nist.gov/service/gpstrace.htm
- Data can be used to compare remote clocks to UTC(NIST) without the common-view receivers

One-way Operation at NIST

GPS monitoring data for 2004-08-22
(as received at NIST in Boulder, Colorado)

Allan Deviation

Averaging Time (τ) (hours, minutes)	Samples	Frequency Stability
0 h, 10 min	142	1.81×10^{-12}
0 h, 20 min	140	1.00×10^{-12}
0 h, 40 min	136	6.23×10^{-13}
1 h, 20 min	128	4.82×10^{-13}
2 h, 40 min	112	3.79×10^{-13}
5 h, 20 min	80	1.19×10^{-13}

Time Deviation

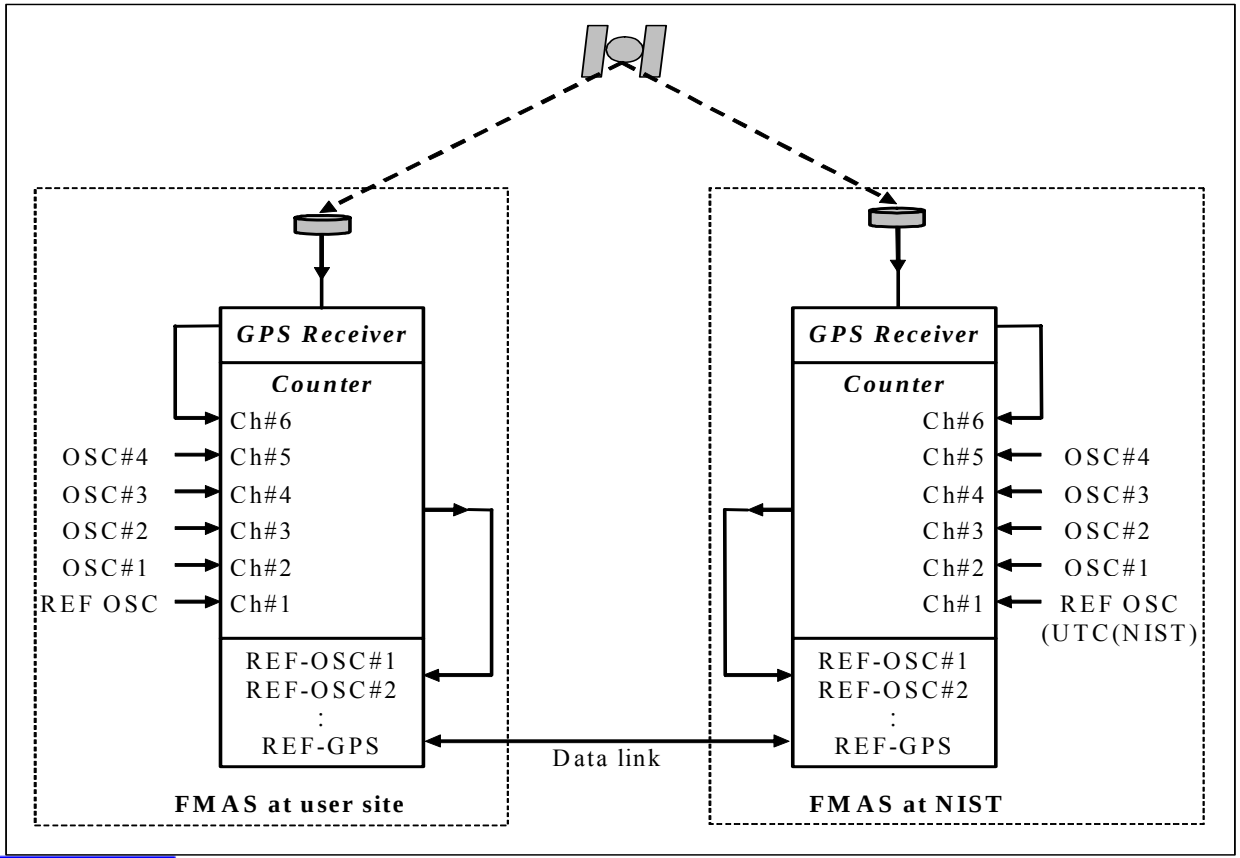
Averaging Time (τ) (hours, minutes)	Samples	Time Stability (ns)
0 h, 10 min	142	0.63
0 h, 20 min	139	0.52
0 h, 40 min	133	0.60
1 h, 20 min	121	1.08
2 h, 40 min	97	1.67
5 h, 20 min	49	0.80

GPS PRN - UTC(NIST)
(data from individual GPS satellites)

GPS PRN	Minutes (In-View)	Mean Time Offset	Range (ns)	Time Deviation	Frequency Offset	Confidence (r)	View Track
1	400	+25.29	16.15	1.40	$+2.1 \times 10^{-13}$	+0.38	View
2	---	---	----------	-------	----------	------	----
3	430	+18.51	19.25	1.26	$+1.1 \times 10^{-14}$	+0.06	View
4	310	+16.35	15.00	1.52	-4.3×10^{-13}	-0.75	View
5	380	+20.72	18.35	2.09	$+3.0 \times 10^{-15}$	+0.01	View
6	320	+18.98	10.15	0.74	$+2.1 \times 10^{-13}$	+0.49	View
7	380	+16.76	9.65	0.67	-2.2×10^{-13}	-0.63	View
8	360	+15.10	20.95	0.85	$+1.0 \times 10^{-13}$	+0.57	View
9	410	+19.11	16.45	1.19	-6.1×10^{-14}	-0.29	View
10	370	+17.06	12.90	1.05	$+7.7 \times 10^{-14}$	+0.55	View

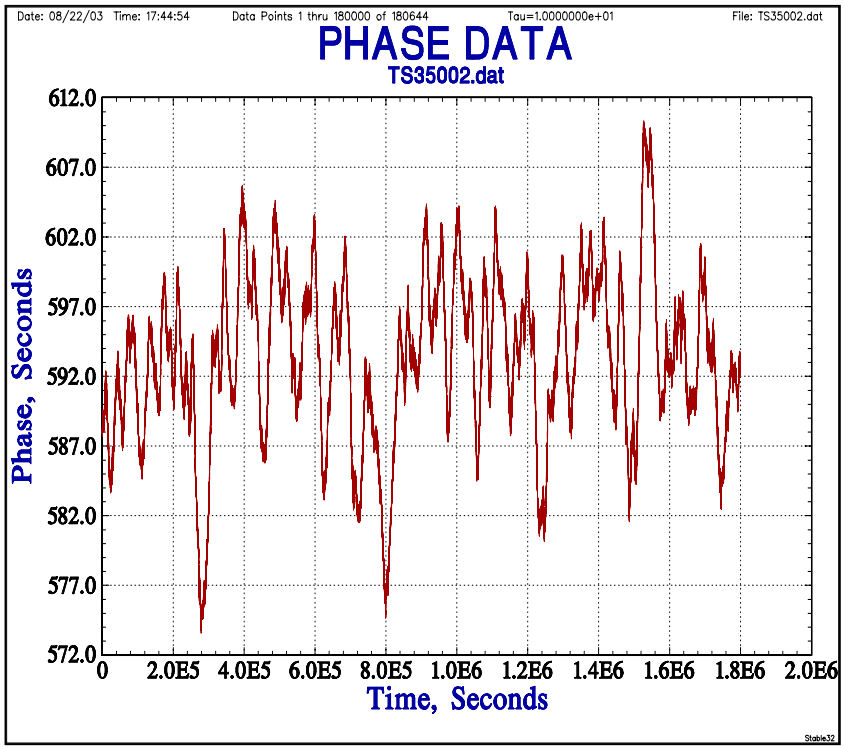
Frequency Measurement and Analysis Service

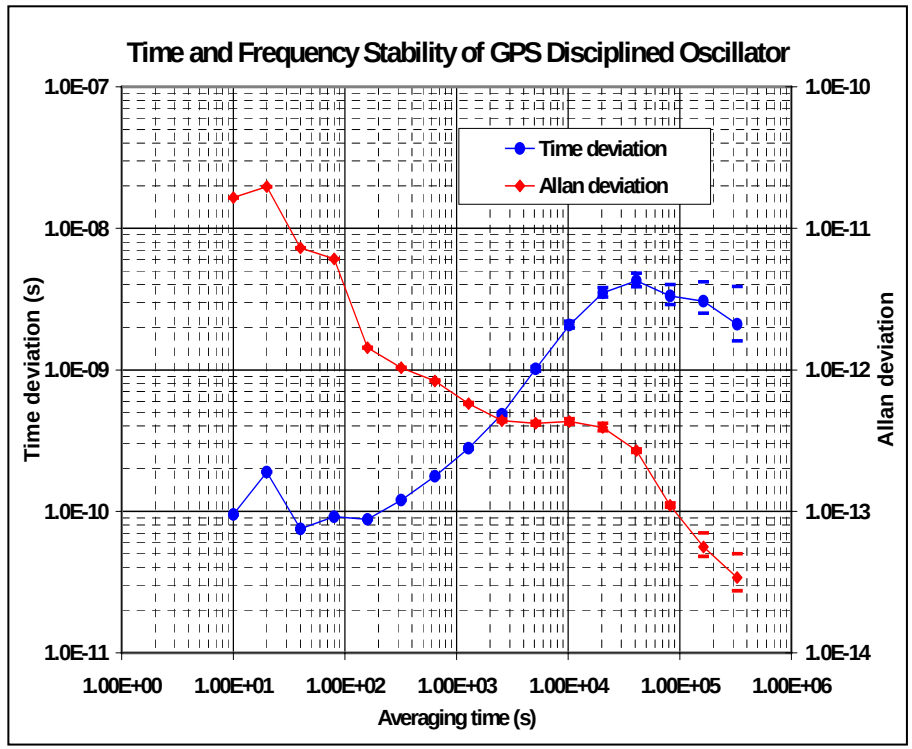
(Service ID No. 76100S) http://tf.nist.gov/service/fms.htm



Calibrate GPS Disciplined Oscillator

(Service ID No.76120S)





Contact: Tom Parker, tparker@boulder.nist.gov

Carrier-phase Operation at NIST

- NIST-PTB link
- Collaboration with University of Colorado

  (contact: Judah Levine, jlevine@boulder.nist.gov)
- Multi-purpose geodetic receiver with Precise Point Positioning analysis software
  - ☞ Receiving GPS and WAAS signals
  - ☞ Data for multi-channel common-view, carrier-phase, and geodetic survey applications
  - ☞ contact: Marc Weiss, *mweiss@boulder.nist.gov*

Carrier-phase Operation at NIST